ABSTRACT

THE EFFECT OF ALTITUDE EXPOSURE: VIA REBREATHING ON INTERVAL PERFORMANCE

by Christopher Curtis Baldwin

The purpose of this experiment is to examine how interval performance is affected with acclimatization to simulated altitude. A total of 17 subjects participated in the experiment. The subjects had blood drawn for examination of hematological values pre and post-treatment. The subjects performed an initial VO$_2$max, 90% interval test, and a repeated Wingate test. The treatment consisted of 15 days of 15 minutes a day utilizing a rebreather as a placebo or hypoxia treatment. Following the treatment the two groups had their blood drawn. The 90% interval test and repeated Wingate test were performed post-treatments. There was a significant difference between hypoxia group’s pre-test and post-hemoglobin values and time during stage 3 of the 90% interval test. It is concluded that simulated altitude via rebreathing apparatus has a beneficial affect on performance. The increases in hematological values were correlated with the increase in performance on the 90% interval test.
THE EFFECT OF ALTITUDE EXPOSURE:
VIA REBREATTHING ON INTERVAL PERFORMANCE

A Thesis

Submitted to the
Faculty of Miami University
in partial fulfillment of
the requirements for the degree of
Master of Science
Department of Kinesiology and Health
by
Christopher C. Baldwin
Miami University
Oxford, OH
2011

Advisor _____________________________
Mark S. Walsh, PhD

Reader ______________________________
Ron H. Cox, PhD

Reader ______________________________
J. Brett Massie, PhD
Table of Contents

<table>
<thead>
<tr>
<th>Chapter One: Introduction</th>
<th>P. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter Two: Methods</td>
<td>P. 7</td>
</tr>
<tr>
<td>Chapter Three: Results</td>
<td>P. 11</td>
</tr>
<tr>
<td>Chapter Four: Discussion</td>
<td>P. 14</td>
</tr>
<tr>
<td>References</td>
<td>P. 18</td>
</tr>
<tr>
<td>Appendix A: Consent form</td>
<td>P. 36</td>
</tr>
<tr>
<td>Appendix B: Medical History Form</td>
<td>P. 37</td>
</tr>
</tbody>
</table>
# List of Tables

Table 1: Subject characteristics  
Table 2: Correlation of hematological values, time, and VO$_2$max  
Table 3: Performance test and hematological value characteristics  
Table 4: Difference scores
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Red blood cell levels pre-test to post-test</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Hemoglobin levels pre-test to post-test</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>Hematocrit levels pre-test to post-test</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>Absolute VO(_2)max pre-test to post-test</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td>Stages 1 – 5 experimental time</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>Stages 1 – 5 control time</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>90% interval total time</td>
<td>31</td>
</tr>
<tr>
<td>8</td>
<td>Testing schedule</td>
<td>32</td>
</tr>
<tr>
<td>9</td>
<td>Oxygen saturation curve</td>
<td>33</td>
</tr>
<tr>
<td>10</td>
<td>AltoLab rebreathing apparatus</td>
<td>34</td>
</tr>
</tbody>
</table>
Dedication

I would like to dedicate this to my friends and family. Thanks for all your help through all my years.
Chapter One: Introduction

Introduction

Altitude training is frequently used by athletes to improve sea-level performance. This type of training became popular during the 1968 Summer Olympic Games, which was held in Mexico City. Results for these Olympic Games showed that sprinters and jumpers set world records; however, distance runners’ finish times were markedly slower than world record times. Another interesting occurrence seen in the 1968 Olympic Games was that athletes from countries like Kenya and Ethiopia, altitude-based countries, won a higher percentage of medals in the middle and long distance races when compared with countries residing at lower altitudes. These two occurrences began the push for better training programs and the start of research in altitude training.

Upon exposure to altitude, several physiological adaptations occur when individuals are exposed to high altitude that the body finds a way to compensate for the lower O$_2$ saturation. One of these compensations is the increase in red blood cell (RBC) and hemoglobin (Hgb). It has been shown that endurance athletes gain a performance advantage with the increased RBC and Hgb in circulations. Therefore, it is also possible that these increases in RBC and Hgb levels may also transfer to performance in interval sports (Woods, Dowson, & Hopkins, 2006).

Upon entering the nose and mouth, the oxygen in the atmosphere diffuses into the lungs. From there the oxygen binds to RBC, more specifically the Hgb, the iron-containing heme group that conducts oxygen transport from the lungs to the rest of the body. During acclimatization to high altitude the body adapts physiologically to the lower O$_2$ saturation and pressure. This adaptation has the potential to improve O$_2$ transport to skeletal muscle during exercise and to enhance performance (Levine & Stray-Gundersen, 1995; Woods, Dowson, & Hopkins, 2006).

The affinity for O$_2$ binding to hemoglobin is determined by partial pressure of inspired oxygen (P$_i$O$_2$), barometric pressure, and O$_2$ concentration. The equation that determines how effectively O$_2$ can bind is determined by P$_i$O$_2$ = (760 mm Hg – 47 mm Hg) x 0.2093 = 149 mm Hg. The P$_i$O$_2$ in the lungs is slightly diminished as it travels from the nose and mouth to the lungs. Upon entering the lungs the P$_i$O$_2$ is only 105 mm Hg (more commonly referred to as the partial pressure of oxygen at the alveolar level of the lungs (P$_{A}$O$_2$)) compared to the partial pressure of oxygen of arterial blood (P$_a$O$_2$) which is only 40 mm Hg. Thus, a concentration
gradient of O₂ entering and exiting the body exists which allows for effective binding of O₂ to hemoglobin (Wilber, 2004; Alberts, 2009). This is an example of the pressure of oxygen as it enters our nose and mouth at sea level.

When utilizing this example to explain the decrease in oxygen saturation at altitude it is easy to understand the decrease in performance. As altitude increases, the P₁O₂ also decreases. This affects the pressure of O₂ entering the lungs (a lower pressure) and in return the concentration gradient for diffusion is not as great, thus reducing the oxygen saturation at altitude.

When the blood circulates through the body, the lower PₐO₂ in the kidney signals a release of erythropoietin (EPO), a key hormone in erythrocyte and hemoglobin production. In return, EPO stimulates erythropoiesis thus causing an increase RBC and Hgb content. In return, the body’s ability to transport oxygen is increased by the increase in RBC mass and Hgb content (Richalet et al., 1994; Wilber, 2004).

It is interesting to note that one study conducted by Julian et al. (2003) found that intermittent normobaric hypoxia had no significant effect on performance or erythropoietic markers in highly trained distance runners. The performance of their subjects maintained the current level. It was suggested that perhaps the method utilized to increase performance was not sufficient (5 minutes of hypoxic air to 5 minutes of ambient air for 70 minutes). However, many of these experiments involve the use of participants who generally reside at sea level. It is known that evolution creates beneficial adaptations over millions of years so it would be expected that differences between performance at altitude may be seen in individuals who have resided at altitude for generations compared to another group that recently established a village.

Ge et al., (1994) examined the effects of higher exercise performance and lower VO₂max between native Tibetan residents and transient Han residents at an altitude of 4,700m. Han natives were acclimatized for a period of 3.2 ± 1.1 years before the study was conducted compared to the Tibetan subjects who were born at 4,700m. To determine if native altitude residents adapt differently than newcomers, values for VO₂max, minute ventilation, anaerobic threshold (AT), blood lactate, and blood gases during exercise were recorded. The Tibetan natives showed a lower VO₂max than the Hans (30.4 ± 1.5 vs. 36.0 ± 1.9 ml · min⁻¹ · kg⁻¹ STDP; P < 0.05), The Han subjects also exhibited a higher maximal exercise effort at a greater exercise workload (167.7 ± 4.2 vs. 150.0 ± 5.9 W; P < 0.05). The mean AT values in the
Tibetan and Han subjects were 84.1 and 61.6% \( (P < 0.01) \) respectively, which showed that Tibetans were capable of maintaining a higher relative effort. The minute ventilation at VO\(_{2}\)max was significantly lower in Tibetan than Han \( (68.4 \pm 3.4 \text{ vs. } 79.7 \pm 4.1 \text{ l/min BTPS}; P < 0.05) \) with an equivalent maximal heart rate for the two groups (Ge et al., 1994).

As seen in the Han subjects, altitude produced physiological adaptations in order to improve an individual’s oxygen carrying capacity. A well-documented physiological adaptation to a decrease in \( P_{I}O_{2} \) is the increased release of EPO. The release of EPO increases the production of RBC, and the increase in RBC is correlated with the absolute maximal oxygen uptake (VO\(_{2}\)max) (Schmidt, W., Spielvogel, H., Eckardt, K. U., Quintela, A., & Penaloza, R. 1993; Ekblom, B. & Berglund, B. 1991). Another method that has produced similar results is commonly referred to as blood doping, utilizing recombinant erythropoietin (Brugnara, Chambers, Malynn, Goldberg, & Kruskall 1993). However, this method is considered cheating and is on the list of banned illegal performance enhancing drugs for the World Anti Doping Agency.

Beginning in the mid 1990s, athletes have been seeking an alternative training method to living high-training high (LHTH) to improve performance, which had been the most commonly used training style until that time. Living high-training low (LHTL) began to grow in popularity with research done by Levine and Stray-Gundersen (1997). This type of training requires the athlete to live at a moderate altitude \( (2,000 – 2,700 \text{m} / 6,560 – 8,855 \text{ ft.}) \) while simultaneously training at low elevation \( (\leq 1,000 \text{ m} / 3,280 \text{ ft.}) \) (Wilber, 2004).

Levine & Stray-Gundersen (1997) were the pioneers of the initial research with LHTL. This study included male and female collegiate runners who were recruited from collegiate track and cross-country teams, running clubs, and USA Track and Field development teams. Athletes were required to be competitive between distances of 1,500 m and marathon and have a recent personal best 5,000 meter time of <16 mins 30 seconds for men and < 18 mins 30 seconds for women.

Participants trained at sea level for a 4 week period, and then athletes were divided into training groups: high-low (LHTL), high-high (LHTH). The study concluded that postaltitude values significantly increased in the LHTL cohort for RBC mass, Hgb, and treadmill VO\(_{2}\)max. However, there were no increases observed in the control group (Levine & Stray-Gundersen, 1997).
The improvement in group performance with LHTL has been well documented although individual variation in performance has not. A study conducted by Chapman, Stray-Gundersen, & Levine (1998) included thirty nine distance runners (27 male and 12 women) from collegiate track and cross-country teams, running clubs and USA Track and Field development teams. These athletes were required to have competitive times in the 1,500 m and marathon as well as a personal record in the 5,000 m time of <16 min 30s for men and <18 min30s for women.

Participants conducted a 6-week sea-level control period, during which laboratory and performance testing values were determined. Athletes trained at 3 different altitudes: moderate (2,500 – 3,000 m), low (1,200 – 1,400 m), low-intensity “base” training at moderate altitude with high intensity “interval” training at low altitude. The overall conclusion for an increase in performance to altitude was through two mechanistic: an increase VO_{2}max and a training effect, i.e., maintenance of training velocity. At moderate altitude and increase in EPO production was observed, which then enhanced these specific individuals’ bodies’ ability to transport O_{2} to the skeletal muscles increasing overall exercise performance. The participants who exhibited the increased EPO had an increase in total red cell volume which led to an increased VO_{2}max and improvement in 5,000 m run time (i.e. increasing performance) (Chapman, Stray-Gundersen, & Levine, 1998).

Another interesting occurrence between the subjects of Chapman, Stray-Gundersen, & Levine (1998) was how each individual adapted to the altitude, meaning each of the mountaineer’s EPO response to altitude. The mountaineers’ EPO increased anywhere from 10.1 mU/ml to 16.3 mU/ml, 25th and 75th percentile. Due to these findings one can say that individuals have a unique response to similar altitudes. The mountaineers who showed responses in the 75th percentile performed better when compared to the 25th percentile mountaineers. However, these EPO increases may also play a detrimental role on exercise performance.

In another study, four subjects native to sea level (P_{B} = 756 mmHg) who participated in intramural soccer in Lima, Peru were chosen to be transported to an altitude of 4,350m, P_{B} = 461 mmHg. After exposure to altitude for 1 day (tests conducted on day 2), these subjects exhibited a decrease of 14% in maximal work, 12% stroke volume, and 6 heart rate beats and by day 10, further decreases in maximal oxygen uptake, cardiac output, heart rate and stroke volume. It was concluded that the peripheral resistance increased as time increased at altitude leading to the decreased stroke volume and in return a decrease maximal oxygen uptake performance (Vogel,
Hartley, Cruz, & Hogan, 1974). In this study the peripheral resistance increased because of the EPO response to altitude, which has been shown to benefit elite endurance athletes.

During high intensity exercise elite athletes exhibit a decreased arterial oxygen saturation (SaO2) at altitude. In general, this decrease in SaO2 is higher than the average person due to the endurance athlete’s ability to circulate oxygen to the working tissue. As previously mentioned, the P1O2 at altitude hinders oxygen’s ability to diffuse into the blood from the lungs. However, this is compounded by the elite athlete’s high cardiac output (Q) and reduced pulmonary capillary transit time decreasing the time for O2 bind to the hemoglobin. Even though the hemoglobin content is higher in trained versus untrained, it is not enough to prevent such SaO2 from occurring even at moderate altitudes, 580m in the current study by Gore et al. (1996).

As Gore et al. (1996) showed, as altitude increases there are decreases in VO2max at altitude for two reasons: a decrease in SaO2, and P1O2. These findings are further supported by a study conducted by Sutton, et al. (1988) who showed that there was a significant decrease in VO2max with simulated altitude. This particular study simulated barometric pressures equivalent to that of Mount Everest. The subjects in this specific study exhibited VO2max values equivalent to 28% of sea-level values (1.17 vs. 4.13 L/min). Similar findings of a decrease in VO2max were also observed in several other studies (Stenberg, Ekblom, & Messin, 1966; Adams, Bernhauer, Dill, & Bomar Jr., 1975). One reason for that may be the decrease in SaO2.

Burtscher, Faulhaber, Flatz, Likar, & Nachbauer (2006) showed that upon acute exposure to altitude the decrease in SaO2 attributed to 99% of the variance in aerobic performance. However, after 45 hours at altitude an attenuation in SaO2 was observed which attributed to 97% variance of the 50% recovery in aerobic performance. Even though it was shown that SaO2 improved only after 45 hours of exposure, full recovery of performance was not observed, which was attributed to the body’s inability to maintain a maximum ventilation necessary to maintain the SaO2.

Blood lactate concentrations also affected endurance performance at altitude. Blood lactate increased by 75.3% at 3,200m with a 15% decreased arterial oxygen saturation. However, an individual’s ventilation increased by 13% from 600m to 3,200m. The increased ventilation could not compensate for the decreased arterial oxygen saturation and increased lactate. (Burtscher, Faulhaber, Flatz, Likar, & Nachbauer, 2006). However, as workout time decreased, maximum ventilation had less of an effect.
A 5-min cycle ergometer test exhibited a slight decrease (12%) upon acute exposure to altitude, 600m to 3,200m, and remained unchanged after short term acclimatization, 45 hours. The duration of this test may have been too short for physiological affects that occur in the 50 minute exercise test to have similar compensations. These results may support that the 5-min exercise test functions similarly to the 30-second cycle ergometer test which had no decrease in performance (Burtscher, Faulhaber, Flatz, Likar, & Nachbauer, 2006).

A majority of sports are not solely aerobic based. Many of them require anaerobic interval work. However, much of the research that has been conducted to this point examines the effect of altitude or simulated altitude exposure on aerobic or anaerobic. The study done by Wood, Dowson, & Hopkins (2006) examined the anaerobic benefits of simulated altitude exposure on male hockey and soccer players. They concluded that there was an enhancement in endurance speed and repeated sprints lasting up to 12 days after exposure. These results seem to indicate that exposure to altitude may be beneficial to performance in elite athletes in anaerobic as well as aerobic situations.

**Purpose**

I propose to further this investigative work by analyzing the benefits obtained after altitude exposure via re-breathers by healthy college aged students. This study will attempt to gain further knowledge concerning the benefits of utilizing re-breathers in order to improve interval exercise, which is experienced in a majority of sports. These findings will give insight into a possible increase in performance, potential benefits of utilizing re-breathers to heighten interval performance, and insight into the pathway in which hypoxia can increase performance at sea level.

**Hypothesis one**

The group exposed to hypoxic conditions will have increased hematological values.

**Hypothesis two**

The group exposed to hypoxic conditions will have increased duration on the 90% VO$_2$ interval test (3 minutes up at 90% and 3 minutes at the walk). They will also have a decreased power drop in the repeated wingate test (5 15-second intervals with 1 minute pedaling recovery).
Chapter Two: Method

Method

The study was randomized with two groups, a placebo and a hypoxia group. The primary researcher and assistant administered the two treatments. Prior to exposure to the rebreathing apparatus, the subjects performed three exercise performance tests: a VO$_2$ max, 90% VO$_2$ interval test, and a repeated Wingate. The 90% VO$_2$ interval test consisted of a 3-minute walk at 5.95 km/h with a maximum 3 minutes at the intensity of the last stage of the VO$_2$ max. This interval was repeated five times. The wingate test consisted of six 15-second intervals with 1 minute of pedaling recovery with an unweighted wheel. The subjects received one-day rest between each of the pre-tests. The wingate and 90% VO$_2$ test were performed post-test. These two tests were performed 5 days post-rebreathing to allow erythrocytes to fully mature from simulated altitude exposure (Flaharty et al., 1990).

The participants underwent hypoxia and placebo treatment for 15 days for 15 minutes each day. The hypoxia treatment was produced using re-breathing devices (ALTO$_2$ Lab, Douglas Pharmaceuticals, Auckland, NZ). The re-breathing device consisted of a tube attached to an open-ended silo containing sodalime (Sodasorb, Chicago, IL) that absorbed carbon dioxide (CO$_2$). The device also consisted of foam-filled silos that increased both respiratory dead space and the hypoxia stimulus. Subjects were required to wear nose clips to prevent nasal breathing and pulse oximeters, which determined oxygen saturation. The placebo device had an identical setup, but it did not contain the Sodasorb to absorb the CO$_2$ (Wood, M.R., Dowson, M.N., & Hopkins, W.G., 2006). Several protocols have been approved for simulated altitude exposure via the rebreathing. ALTO$_2$Labs breathing protocol included 15 days for 15 minutes; Wood, Dowson, & Hopkins (2006) administered a 6 minutes on and 4 minutes off for an hour each day and showed performance enhancements. However, Babcock (2007) showed that a 15-minute protocol had the same effects as the 60-minute protocol recommended by ALTO$_2$Lab.

Blood

A hematological profile was performed prior to exposure to daily hypoxia or the placebo treatment for all subjects. A hematological profile was administered post treatment exposure to
daily hypoxia or the placebo treatment for all subjects. The hypoxia group had blood sampled five days post rebreathing in order to fully allow for erythrocyte maturation (Flaharty et al., 1990). The Miami University Student Health Center sampled blood for the profile exposure.

Measures of blood lactate levels were taken 5 times during the 90% VO₂ interval test. Each lactate sample was taken from the left hand approximately 1 minute 30 seconds into each of the walk stages (5.95 km/hr).

**Subjects**

Subjects consisted of volunteers with ages that ranged from 18-25, both male and female. Subjects were volunteers who were currently students from the Miami University, Oxford campus. A total of 16 subjects, volunteers from the Miami University, Oxford campus, participated in the study. The first cohort consisted of 12 volunteers, 6 placebo treatment and 6 hypoxia treatment. The subjects were performance matched to assigned groups, either placebo treatment or hypoxia treatment. The second cohort consisted of 5 volunteers, 1 placebo treatment and 4 hypoxia treatment. The subjects were performance matched and assigned to groups, placebo treatment or hypoxia treatment. The subjects in both cohorts were of equal fitness levels. All subjects gave voluntary informed consent as required by the Internal Review Board.

**Training**

During the study, subjects were asked to maintain their existing training regimen prior to baseline testing and the last performance trial. Subjects were instructed not to engage in extremely strenuous exercise 24h prior to performance trials.

**Hypoxia Treatment**

In the treatment sessions, subjects were required to breathe through the device for 15 minutes. Oxygen saturation was monitored with individual pulse oximeters provided by ALTO₂Lab. Saturation was reduced to 90% on day 1-5, to 87% on day 6-10, and 84% on days 11-15. These three oxygen saturation values correspond approximately to 3800m, 4000m, and 4500m at day 15 (<http://www.high-altitude-medicine.com/SaO2-table.html>, from Reference [Wood, Dowson, & Hopkins, 2006]). Subjects were not allowed to view the pulse oximeters. Refer to Figure 1.
Exercise Performance Tests

Subjects performed an initial VO₂max test on visit 1. On visit 2 (at least one day of rest required), subjects performed a series of interval tests administered on a treadmill (90% VO₂ interval test). The participants began with a 3-minute warm-up at a pace of 5.95 km/h. Following the warm-up, the participants were asked to run at the intensity of the last stage of their VO₂max for at most a 3-minute interval followed by a 3-minute walk at 5.95 km/h. The subjects were asked to perform 5 cycles of the interval work.

The modified Wingate test (six 15-second intervals with 1 minute pedaling recovery) was also performed on visit 3 (1 or 2 days after interval work).

After the subjects completed the 15-day breathing protocol (visit 18), the hypoxia group was asked to come in 5 days later and perform a post 90% VO₂ interval test while the placebo group was asked to come in any day following treatment. The participants began with a 3-minute warm-up at a pace of 5.95 km/h. Following the warm-up, the participants were asked to run at the last stage of their VO₂max for at most a 3-minute interval followed by a 3-minute walk at 5.95 km/h. The subjects were also asked to perform 5 cycles of the interval work. If the subjects were at the point of failure, they were instructed to step on the side of the treadmill to inform the researcher that they could physically go no longer. The subjects were asked to perform 5 cycles of the interval work.

The modified Wingate test may also be performed on visit 19 (1 or 2 days after interval work). Refer to Figure 1.

Blood Measurements

The index finger of the subject’s left hand was used as a sample site for blood lactate values. A sterile, single use lancet was used to puncture the skin. The blood was placed on a strip for the portable lactate analyzer (Accutrend ® Lactate).

Subjects visited the Miami University Health Center for determination of blood values: hematocrit (HCT), Hgb, and RBC.

Apparatus
Alto₂Lab altitude simulators work by effectively lowering your SaO₂ due to the individual’s having to rebreathe the exhaled air. The re-breathing apparatus contains a filter and hypoxic silo that removes the carbon dioxide (CO₂) from exhaled air. In another set of containers, AltoMixers, the oxygen content of inhaled air is lowered by mixing with the 16% O₂.

The inhaled O₂ from the atmosphere is 21% and CO₂ is 0.04% while the exhaled air is 16% O₂ and 4% CO₂. Upon each exhalation the CO₂ is removed in the hypoxic silo, green canister. In the AltoMixer canisters, the exhaled air is mixed with the fresh air with each breath. During repeated re-breathing the O₂ saturation is slowly lowered to the desired altitude. The more AltoMixer stacks attached, the greater the altitude achieved (each AltoMixer equals approximately 5000 feet or 1500 meters). Refer to Figure 9 (ALTO₂Lab, Douglas Pharmaceuticals, Auckland, NZ).

Practical Implications

The research conducted thus far has focused on aerobic and anaerobic performance while few studies have examined the effect of re-breathing apparatuses on interval performance. Major conclusions have been drawn concerning the benefit for aerobic and anaerobic performance. When examining the effect on aerobic performance, there are more than likely benefits from the utilization of a rebreathing device or exposure to altitude as with LHTL paradigm. However, benefits in aerobic performance may not be seen in extremely skilled athletes (Levine & Stray-Gundersen, 1997; Dehnert et al., 2002) In contrast, the conclusions drawn about anaerobic performance show that there is more than likely no significant benefit with this type of training (Burtscher, Faulhaber, Flatz, Likar & Nachbauer, 2005). This study is unique in considering the effects of altitude training on interval performance. With the inclusion of the results from this study, a more in depth understanding of how altitude can enhance or hinder performance will be drawn. It is expected that the simulated altitude will have a beneficial effect on measured performance variables (time and power drop) and hematological variables.
Chapter Three: Results

Results

Subjects

Seventeen subjects, 7 male and 10 female (Table 1), completed the hypoxia or placebo protocol. However, 1 male subject was noncompliant with the breathing protocol and had his data discarded. All 17 subjects completed the VO2max and 90% VO2 interval test protocol that were administered. Two female times in the hypoxia group for the 90% VO2 interval test were discarded since the two participants completed all 900 possible seconds in the pre-test, therefore leaving no possible way to determine if there was an increase in performance post-test. One female in the placebo group had her time discarded since all five intervals in the 90% VO2 interval test were not attempted for the pre-test.

The Wingate test was conducted for the first cohort of subjects for pre-test and post-test. However, upon examination of the bike during the post-test it was determined that mechanical issues were present. Therefore, the data for the first cohort was all discarded. The Wingate test was not administered to the second cohort for mechanical reasons. All 17 subjects had their blood values taken pre-test and post-test. However, 1 male subject in the hypoxia group was noncompliant, and his values were discarded.

Preliminary Analysis

Blood Independent t-tests were used to examine the differences between group pre-test RBC, Hgb, and HCT. The means and standard deviations for RBC, Hgb, and HCT are presented in Table 3. The main effect for RBC was not found to be significant, $F(1, 14) = 4.22, p = 0.59$, partial $\eta^2 = 0.23$. The main effect for Hgb was not found to be significant, $F(1, 14) = 1.73, p = 0.21$, partial $\eta^2 = 0.11$. The main effect for HCT was not found to be significant, $F(1, 14) = 3.94, p = 0.7$, partial $\eta^2 = 0.22$.

Time An independent t-test was used to examine the difference between hypoxia and placebo group pre-test 90% VO2 total interval time. The mean and standard deviation for pre-test 90% VO2 total interval time is presented in Table 2. The main effect for time was found to be significant, $F(1, 11) = 0.92, p = 0.04$. 

11
An independent t-test was used to examine the difference between the hypoxia group and placebo group pre-test absolute VO$_2$. The mean and standard deviation for the VO$_2$ pre-test are presented in Table 3. The main effect was found to be non-significant, $F(1, 14) = 3.22, p = 0.10$, partial $\eta^2 = 0.19$.

**Analysis**

**Blood**

A Repeated Measures ANOVA was used to examine the effects of group assignment (hypoxia or placebo) on blood values: The means and standard deviation are presented in Table 4. A significant main effect was found for Hgb, $F(1, 14) = 4.60, p = 0.05$, partial $\eta^2 = 0.25$. A non-significant main effect was found for RBC, $F(1, 14) = 3.35, p = 0.09$, partial $\eta^2 = 0.19$ and HCT, $F(1, 14) = 0.10, p = 0.76$, partial $\eta^2 = .01$.

A set of correlation tests was used to examine significance between RBC, Hgb, and HCT. A significant correlation between RBC and Hgb was found, $r(14) = 0.87, p < 0.01$, RBC and HCT, $r(14) = 0.61, p < 0.05$, Hgb and HCT, $r(14) = 0.69, p < 0.01$.

A multiple regression analysis was conducted to evaluate how well the hematological variables predicted total time spent during the 90% interval test. The predictors were the three blood values: RBC, Hgb, and HCT, while the criterion variable was the total time on 90% interval test. The results of the multiple regression indicated that the correlation coefficient was .62, indicating that 38% of the variance was explained by the three hematological values.

The correlations between hematological values were positive as expected. However, HGB explained 29% (.537 = .29) of the variance while the others explained only 10% (39% - 29% = 10%) of the variance. The correlations of these hematological values ranged from .24 to .54.

**Time**

A Repeated Measures ANOVA was used to evaluate the total time of stages, 1, 2, 3, 4, and 5 between the hypoxia and placebo group from pre-test to post-test. The only stage during which a significant main effect was observed occurred during stage 3, $F(1, 12) = 5.68, p = 0.04$, partial $\eta^2 = 0.32$. Stage 5 did not have a main effect, $F(1, 14) = 3.35, p = 0.07$, partial $\eta^2 = 0.26$. The means and standard deviation are presented in Table 3.
A Repeated Measures ANOVA was used to evaluate the difference between the hypoxia and placebo absolute VO$_2$max values from pre-test to post-test. No significant main effect was found, $F(1, 14) = 2.97, p = 0.10$, partial $\eta^2 = 0.18$.

A correlation test was used to examine the effect of absolute VO$_2$ difference on 90% VO$_2$ total interval time. A significant positive correlation between absolute VO$_2$ and 90% VO$_2$ total interval time was found, $r(11) = 0.56$, $p < 0.05$.

A multiple regression was also used to examine the effects of absolute VO$_2$ difference and HGB difference on total time for interval tests. The results of the multiple regression indicated that absolute VO$_2$ difference and HGB difference explained 53.1% of the variance.
Chapter Four: Discussion

Discussion

The purpose of this research was to determine if individuals who participate in interval sports would benefit from utilization of a rebreathing apparatus that simulates altitude. Several studies have shown that aerobic performance increases with exposure to either simulated altitude or altitude (LHTL); however, very few studies have examined the effects of simulated altitude on interval performance. Through the course of the study several differences appeared between the hypoxia and placebo group: RBC, Hgb, absolute VO₂max, total interval time and total time on stages (specifically stage 3).

Performance is determined by the body’s ability to transport oxygen to working muscles. Many factors have an influence on oxygen carrying capacity. The simulated altitude aims to enhance performance by manipulating the RBC mass and Hgb content via lower oxygen saturation.

The hypoxia group showed markedly improved times from pre-test to post-test when compared to the placebo. Upon examination of the hematological variables a marked increase in RBC and a significant increase in Hgb levels were measured in the hypoxia group when compared to only a slight increase in RBC and slight decrease in Hgb of the placebo group (Refer to Table 6). However, only Hgb values were found to have a significant main effect, $p = 0.05$. These results agree with findings from Richalet et al. (1994) who also reported similar findings with exposure to a hypoxic environment. This suggests that the rebreathing apparatus was an effective way to induce simulated altitude exposure. RBC values also exhibited an increase for the hypoxia group for the post-hematological analysis even though the RBC values were not shown to be significant.

The statistical analysis of RBC revealed a significance of $p < 0.09$. Regardless, an increase in RBC was observed for the hypoxia group (Figure 3). It is worth noting the sample size when reviewing these results ($n = 16$). Even though no significance was found during the course of this study Brugnara, Chambers, Malynn, Goldberg, and Kruskall (1993) showed similar and significant increases in RBC mass in response to recombinant erythropoietin, a hormone that stimulates a similar response to naturally occurring EPO in the human body upon exposure to altitude. Other studies have examined the effect of an increase in RBC mass on
exercise performance. One particular study done by Levine & Stray-Gundersen (1997) observed an increase in VO$_2$\textsubscript{max} with an increase in RBC mass as a result of a similar treatment, LHTL.

An increase in absolute VO$_2$\textsubscript{max} from pre-test to post-test was observed in the hypoxia group (Refer to Figure 4). The increases in absolute VO$_2$\textsubscript{max} were not found to be significant, but other studies have showed similar and significant gains in VO$_2$\textsubscript{max} due a LHTL treatment (Dehnert et al., 2002; Levine & Stray-Gundersen, 1997). The results of the current study may not have been statistically significant due to the small population, but there appeared to be a trend towards improvement in VO$_2$\textsubscript{max}.

This increase in VO$_2$\textsubscript{max} was not statistically significant between the hypoxia group and placebo group from pre-test to post-test. However, the control group remained constant from pre-test to post-test (Refer to Figure VO2). Even though no significant statistical difference was found this might have been due to the small population size utilized for this study. Even though the change in VO$_2$ was not statistically significant it did have an impact on the outcome of total time on the interval test.

The correlation of time (difference scores) to absolute VO$_2$\textsubscript{max} (difference scores) suggests that the higher the VO$_2$\textsubscript{max}, the more likely to have an increase in time from pre-test to post-test. Therefore, one can conclude that even though the two groups did not differ significantly in the absolute VO$_2$\textsubscript{max} values, the times for each of the tests were ultimately determined by the increase in VO$_2$ from pre-test to post-test. This is not an unusual finding. If the rebreathing apparatus has the ability to boost VO$_2$\textsubscript{max} values, a given workload should become easier from pre-test to post-test. This was observed in the hypoxia group’s increase in interval time.

The times between the hypoxia and placebo group from pre-test to post-test were not statistically significant ($p = 0.055$). Again this may be due to the small population size. There was an average improvement of 87.57 seconds for the hypoxia when compared to the placebo with a slight increase of 8.67 seconds. All things being equal, the placebo group should have remained constant and no increase should have been observed, but as previously mentioned this group did have a slight increase in RBC (0.03 μ/L). This increase may have contributed to the slight improvement in total time.

An interesting observance in the hematological blood values was the linear increase for hypoxia and placebo groups in the hematocrit values. It was expected that the hypoxia groups'
hematocrit values would have increased from pre-test to post-test, which was the case. However, placebo group should have remained constant since no treatment administered would stimulate a change in hematological values. However, increases in the hypoxia and placebo group from pre-test to post-test were observed, 1.63 % and 1.18%, respectively. This is not of much concern when considering performance since the two main factors that would have a greater effect on increased performance are RBC and Hgb. As previously stated, RBC and Hgb values increased for the hypoxia group (4.53 to 4.70 μ/L and 13.21 to 13.69 g/dL, respectively) while the placebo group had only a slight increase (4.58 to 4.59 μ/L) and decrease (14.46 to 14.34 g/dL) respectively. One reason that the hematocrit levels may have increased in both groups could have been attributed to dehydration. It is more than likely that all participants had the post hematological values taken from the Miami University Health Center after the post 90% VO2 interval performance test. This would have increased overall RBC and Hgb in the lower plasma volume.

The hypotheses were partially supported due to the treatment condition. Even though statistical significance was not found in a majority of the data, which was likely due to the low subject population, there did appear to be a beneficial trend for the hypoxia group with utilization of the rebreathing apparatus that simulated altitude. The overall time increase from pre-test to post-test was approximately 10 times more for hypoxia than control, 87.57 seconds and 8.67 seconds respectively. It is worth mentioning that the difference between these two values can have a significant impact on any sport involving interval bouts. One specific example would be the 2:00 minute drill in football. The wide receiver may gain a slight advantage during repeated plays, which may alter the outcome of the game.

**Limitations**

There are several limitations when conducting any study. One major limitation of this study was the design; it limited the inclusion of a large sample for analysis. A significant amount of time was necessary for each participant to undergo the approximate 4 to 4.5 week treatment process. Due to the small number of subjects who participated, significant main effects were hard to achieve along with low power observed for several of the observed variables. Another disadvantage to the low population was the inability to separate male subjects from female subjects. High standard deviations were observed in all the variables; one reason these standard
deviations were observed was because the average values for males and females are different. For all of the examined variables the average is higher for males compared to females. The only exception to this is the variable of time. These were not the only limitations of the study.

Another limiting factor of the study was a possible alteration in an individual’s training regime. Even though subjects were instructed to maintain a constant program without increasing or decreasing training, several subjects mentioned upon completion of the study that in some way their training was altered through the course of the study. This is interesting to note since subjects in both groups mentioned this type of change in activity.
References


### Table 1.
*Subject characteristics (n = 16)*

<table>
<thead>
<tr>
<th></th>
<th>Hypoxia</th>
<th>Placebo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (y)</strong></td>
<td>22 ± 2.5</td>
<td>21 ± 1.0</td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>69.88 ± 16.54</td>
<td>66.91 ± 12.15</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>171.11 ± 10.08</td>
<td>170.29 ± 14.86</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>4 M, 5 F</td>
<td>2 M, 5 F</td>
</tr>
</tbody>
</table>
Table 2.

Correlation of hematological values, time, and VO$_2$max

<table>
<thead>
<tr>
<th></th>
<th>Red Blood Cell</th>
<th>Hemoglobin</th>
<th>Hematocrit</th>
<th>Absolute VO$_2$max</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood Cell</td>
<td>--</td>
<td>.870**</td>
<td>.612*</td>
<td>.142</td>
<td>.352</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>.870**</td>
<td>--</td>
<td>.686**</td>
<td>.148</td>
<td>.537</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>.612*</td>
<td>.686**</td>
<td>--</td>
<td>-.212</td>
<td>.244</td>
</tr>
<tr>
<td>Absolute VO$_2$max</td>
<td>.142</td>
<td>.148</td>
<td>-.212</td>
<td>--</td>
<td>.559*</td>
</tr>
<tr>
<td>Time</td>
<td>.352</td>
<td>.537</td>
<td>.244</td>
<td>.559*</td>
<td>--</td>
</tr>
</tbody>
</table>

Note. $p<.05$; **$p<.01$
### Table 3.

*Performance test and hematological value characteristics*

<table>
<thead>
<tr>
<th></th>
<th>Hypoxia (n = 7)</th>
<th>Placebo (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td><strong>Total Interval</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (sec)</td>
<td>625.86 ± 122.79</td>
<td>713.43 ± 159.70</td>
</tr>
<tr>
<td><strong>Stage 1 (sec)</strong></td>
<td>180.00 ± 0.00</td>
<td>172.14 ± 20.79</td>
</tr>
<tr>
<td><strong>Stage 2 (sec)</strong></td>
<td>135.00 ± 49.86</td>
<td>155.14 ± 32.21</td>
</tr>
<tr>
<td><strong>Stage 3 (sec)</strong></td>
<td>106.14 ± 27.39*</td>
<td>142.57 ± 37.87*</td>
</tr>
<tr>
<td><strong>Stage 4 (sec)</strong></td>
<td>105.57 ± 26.35</td>
<td>124.00 ± 51.50</td>
</tr>
<tr>
<td><strong>Stage 5 (sec)</strong></td>
<td>98.71 ± 24.48</td>
<td>119.57 ± 32.00</td>
</tr>
<tr>
<td><strong>Absolute VO_2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(L/min)</td>
<td>3.42 ± 1.20</td>
<td>3.58 ± 1.25</td>
</tr>
<tr>
<td><strong>Blood parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red blood cell</td>
<td>4.53 ± 0.48</td>
<td>4.70 ± 0.49</td>
</tr>
<tr>
<td>(μL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>13.21 ± 2.16*</td>
<td>13.69 ± 2.28*</td>
</tr>
<tr>
<td>Hematocrit %</td>
<td>39.79 ± 5.98</td>
<td>41.42 ± 5.83</td>
</tr>
</tbody>
</table>

Note. Means and standard deviations, *p<0.05
Table 4.

**Difference Scores**

<table>
<thead>
<tr>
<th></th>
<th>Hypoxia ((n = 7))</th>
<th>Placebo ((n = 6))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Time Interval (sec)</td>
<td>87.57 ± 72.03</td>
<td>8.67 ± 58.47</td>
</tr>
<tr>
<td>Blood parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red blood cell (\mu/L)</td>
<td>0.17 ± 1.6</td>
<td>0.03 ± 0.19</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>0.48 ± 0.62*</td>
<td>-0.02 ± 0.48</td>
</tr>
<tr>
<td>Hematocrit %</td>
<td>1.63 ± 1.88</td>
<td>1.27 ± 1.88</td>
</tr>
</tbody>
</table>
Change in Red Blood Cell Pre to Post

<table>
<thead>
<tr>
<th>Red Blood Cell (μ/L)</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Change in Hemoglobin Pre to Post

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>14.5</td>
<td>13.8</td>
</tr>
<tr>
<td>Post</td>
<td>15.2</td>
<td>14.9</td>
</tr>
</tbody>
</table>

Hemoglobin (g/dL)
Change in Absolute VO₂ Pre to Post

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Absolute VO₂ (L/min)
Experimental Time Pre to Post

<table>
<thead>
<tr>
<th>Stage</th>
<th>Total Time Per Stage (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Pre: 180.00, Post: 180.00</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Pre: 140.00, Post: 140.00</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Pre: 100.00, Post: 100.00</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Pre: 80.00, Post: 80.00</td>
</tr>
<tr>
<td>Stage 5</td>
<td>Pre: 60.00, Post: 60.00</td>
</tr>
</tbody>
</table>

Pre
Post
Control Time Pre to Post

![Bar chart showing total time per stage (sec) for stages 1 to 5, comparing pre and post times.](chart.png)
90% VO₂ Interval Time Pre to Post

![Graph showing 90% VO₂ Interval Time Pre to Post comparison between Control and Experimental groups.](image)
<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4-18</th>
<th>Day 19</th>
<th>Day 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO₂max</td>
<td>90% VO₂</td>
<td>Wingate</td>
<td>Rebreathing</td>
<td>90%VO₂</td>
<td>Wingate</td>
</tr>
<tr>
<td></td>
<td>Interval</td>
<td></td>
<td></td>
<td>Interval</td>
<td></td>
</tr>
<tr>
<td>test</td>
<td>test</td>
<td></td>
<td></td>
<td>test</td>
<td></td>
</tr>
</tbody>
</table>
How it works

1. Inhaled air enters the base of the AltoMixer stack and has the following composition:

    |       |     |
    |-------|-----|
    | 78.5% | N₂  |
    | 21.0% | O₂  |
    | 0.04% | CO₂ |
    | 0.30% | H₂O (vapor) |
    | 100.0%| Total |

2. This air passes up through the Hypoxic silo and into the user's lungs where O₂ is removed and CO₂ and H₂O from the body is expelled. Air now inside the lungs now has the following composition:

    |       |     |
    |-------|-----|
    | 78.5% | N₂  |
    | 13.0% | O₂  |
    | 5.3%  | CO₂ |
    | 6.2%  | H₂O (vapor) |
    | 100.0%| Total |

Note how the O₂, CO₂, and H₂O levels in air change after entering the lungs.

3. Air exhaled from the lungs passes down into the green Hypoxic silo where all CO₂ is removed. As air moves the into the AltoMixer stack it now has the following composition:

    |       |     |
    |-------|-----|
    | 79.8% | N₂  |
    | 14.0% | O₂  |
    | 0.0%  | CO₂ |
    | 6.2%  | H₂O (vapor) |
    | 100.0%| Total |

Air in the AltoMixer stack (14% O₂) mixes with fresh, inhaled air (21% O₂) causing a net change in the O₂ level to (17%). After several breaths, as more O₂ is depleted the net O₂ continues to drop, and has the following composition:

    |       |     |
    |-------|-----|
    | 65.0% | N₂  |
    | 9.0%  | O₂  |
    | 0.0%  | CO₂ |
    | 6.0%  | H₂O (vapor) |
    | 100.0%| Total |

Note that 9.0% O₂ content is equal to about 20,000 ft.
Appendix A: Consent Form

Informed Consent Form

Title of Research Project: **THE EFFECT OF SIMULATED ALTITUDE EXPOSURE: VIA REBREATHING ON INTERVAL PERFORMANCE**

Principal Investigators: Mark Walsh, Department of Kinesiology and Health.

This is to certify that I, ______________________________________, hereby agree to participate as a volunteer in a scientific investigation as an authorized part of the education and research program of Miami University under the supervision of Dr. Mark Walsh, Ph.D.

The investigation and my part in the investigation have been defined and fully explained to me and I understand the explanation. A copy of the procedures of this investigation has been provided to me and has been discussed in detail with me.

* I am above the legally required 18 years of age necessary to participate in this study

I have been given the opportunity to ask questions and all such questions and inquiries have been answered to my satisfaction.

I understand that I am free to deny answers to specific questions in interviews or questionnaires.

I understand that health information will be collected and will be kept in Mark Walsh’s office and will not be available for others.

I understand that in the event of physical injury resulting from the research procedures, financial compensation is not available and medical treatment is not provided free of charge.

* I further understand that I am free to withdraw my consent and terminate participation at any time during the study.*

________________________________________
Participant's Signature

I, the undersigned have defined and fully explained the investigation to the above participant.

________________________________________
Date Investigator's Signature (or that of official representative)

Participants will be provided a copy of this form to keep.
Appendix B: Medical History Form

MEDICAL HEALTH HISTORY
All information you provide is personal and confidential. The information will enable us to better understand you and your health and fitness habits as well as inform you of any potential risks.

NAME ______________________________ ID ______________________________ DATE _____/_____/_____

Address __________________________________________________________________________________________________

City, State Zip __________________________________________________________________________________________________

Employer ______________________________________________________________________________________________________

Phone (H) __________________________ (W) __________________________ Email ____________________________________________________________________________________________

Date of Birth _____/_____/____ Male ______ Female ______

Emergency Contact ___________________________________________________________________________ Phone __________________________ Relation ______________________________

Physician’s Name ___________________________________________________________________________ Phone __________________________ Fax __________________________

GENERAL
Height __________ ft. Weight __________ lbs.

Any unexplained significant weight loss/gain . . . Within the last 6 months Within the last year NO

If yes, please explain:

What was your most recent blood pressure reading? _______/_______ mm Hg Date __________________________

Do you currently exercise? YES NO

If yes, how long have you been exercising regularly?
______________________________________________________________

What exercise do you do and how often?

MEDICAL DIAGNOSES
Have you ever had any of the following?

<table>
<thead>
<tr>
<th>Condition</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart attack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angina</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osteoporosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular surgery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currently pregnant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emphysema</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allergies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rheumatic Fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phlebitis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Any special conditions not listed above:

If you answered, “YES” to any of the above Medical Diagnoses,

It is RECOMMENDED that you consult with your physician before beginning your exercise program.

MEDICATIONS
Please list any medications you are currently taking including but not limited to prescriptions, allergy medications, ergogenic aids, diet supplements, vitamins, minerals, etc.

Medication ____________________________________________________________________________________

Reason ______________________________________________________________________________________

Dosage _______________________________________________________________________________________

______________________________________________________________
MAJOR RISK FACTORS
1. Are you a man over the age of 45 or a woman over the age of 55, YES NO
   Having had a hysterectomy, or are postmenopausal?
2. Has your father or brother experienced a heart attack before age 55? YES NO
   Or has your mother or sister experienced a heart attack before the age of 65?
   Who? 
3. Has your doctor ever told you that you might have high blood pressure? YES NO
4. Do you have cholesterol above 200 ml/dl? YES NO
   Total cholesterol _______ HDL ___________ Date tested ___________ Unknown _____
5. Do you have impaired fasting glucose (diabetes)? YES NO
   If yes – Do you take insulin? YES NO What year were you diagnosed? __________
6. Are you physically inactive (i.e., you get less than 30 minutes of physical activity on at least 3 YES NO
days per week
7. Do you currently smoke or have you quit smoking in the last 6 months?
   I smoke (#)__________ cigarettes per day/week (circle one) for _______ years ago. YES NO
   I smoked (#)__________ cigarettes per day/week (circle one) ________ years ago.
8. Are you > 20 pounds overweight? YES NO
If you are a man over the age of 45 or a woman over the age of 55
OR if you answered “YES” to two (2) or more of the above Major Risk Factors,
It is RECOMMENDED that you receive physician’s clearance before beginning your exercise program.

MAJOR SIGNS/SYMPTOMS
SUGGESTIVE OF CARDIOVASCULAR AND PULMONARY DISEASE
1. Pain discomfort (or anginal equivalent) in the chest, neck, jaw, arms, or other areas
   that may be due to ischemia (decreased blood flow) YES NO
2. Shortness of breath at rest or w/mild exertion YES NO
3. Dizziness or syncope at rest or w/mild exertion YES NO
4. Orthopnea/paroxysmal nocturnal dyspnea (labored breathing) at rest or w/mild exertion YES NO
5. Edema (excessive accumulation of tissue fluid) YES NO
6. Palpitations or tachycardia (sudden rapid heart beat) YES NO
7. Intermittent Claudication (lameness due to decreased blood flow) YES NO
8. Known heart murmur (abnormal heart sound) YES NO
9. Unusual fatigue or shortness of breath with usual activities YES NO
If you answered, “YES” to any of the above Major Signs and Symptoms listed above
Or have known cardiovascular, pulmonary, or metabolic disease (see below for descriptions),
It is STRONGLY RECOMMENDED that you seek physician’s clearance before beginning your exercise program.
Cardiovascular – cardiac, peripheral vascular, cerebro-vascular disease
Pulmonary – Chronic obstructive pulmonary disease, asthma, interstitial lung disease, or cystic fibrosis
Metabolic Disease – Diabetes mellitus (types 1 and 2), thyroid disorders, renal or liver disease.
I understand this Health History Questionnaire has been provided to me for the purpose of helping me better understand any potential
risks associated with a workout program. I also understand I should share this information with my physician and seek his or her approval prior to beginning an exercise program. I understand the information I have provided will be maintained in my membership
file for use in case of a medical emergency. My signature signifies that all of the above is true, to the best of my knowledge. Any information left unanswered was done so intentionally. If any of the above information changes, I agree to submit these changes in
writing to this facility’s wellness professional for an update to my membership file.
Signature: __________________________ Date: ________ Received by: _______________________
Date: __________
I understand this Health History Questionnaire has been provided to me for the purpose of helping me better understand any potential
risks associated with a workout program, to share with my physician in order to obtain his or her approval before beginning an exercise
program, and to be maintained as part of my membership file in case of a medical emergency. I do not want to complete this questionnaire and understand I assume full responsibility for any risks associated with my participation in an exercise program.
Note: All Major Risk Factors, Signs and Symptoms classifications are taken directly from Whaley, Mitchell H, ed. ACSM’s Guidelines for Exercise Testing and Prescription. *Phila*